UNIVERSITY OF ILLINOIS

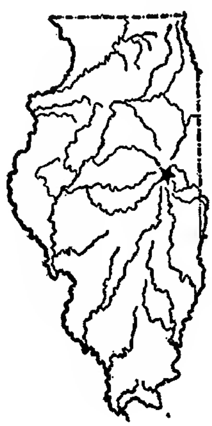
Agricultural Experiment Station

BULLETIN No. 204

GERM CONTENT OF MILK

II. AS INFLUENCED BY THE UTENSILS

By M. J. PRUCHA, H. M. WEETER, and W. H. CHAMBERS



URBANA, ILLINOIS, FEBRUARY, 1918

Contents of Bulletin No. 204

GERM CONTENT OF MILK

II. AS INFLUENCED BY THE UTENSILS

BY M. J. PRUCHA, ASSISTANT CHIEF IN DAIRY BACTERIOLOGY
H. M. WEETER, ASSISTANT IN DAIRY HUSBANDRY, and
W. H. CHAMBERS, ASSISTANT IN DAIRY BACTERIOLOGY

INTRODUCTION

The interval during which milk will remain sweet is an important element of its value, and one for which the producer has been held mainly responsible. Milk sours because of the growth in it of plant life—bacteria. The problem of protecting the keeping quality of milk becomes one of preventing the entrance of bacteria, of destroying them after they enter, or of keeping them so cold as to check their growth. The first interest of the producer is to restrict the number of bacteria getting into the milk, so far as is consistent with the costs involved. To do this he must know the relative importance of the various avenues thru which they may enter.

Additions to our knowledge regarding the relative importance of the various avenues thru which bacteria enter milk have been furnished by a series of experiments conducted at the New York (Geneva)[1] and the Illinois[2] Agricultural Experiment Stations. The most striking result of these studies has been to establish the fact that ordinarily barns have little or no measurable influence upon the germ content of the milk produced in them.

The need of further study to determine the mode of entrance of the large number of bacteria that are regularly found in the public milk supply, being recognized, this investigation, begun in the fall of 1913, was directed toward determining the influence that the various utensils in which milk is normally handled exerts upon the germ content of the milk.

[1]Harding, H. A., Wilson, J. K., and Smith, G. A. Milking Machines: Effect of Method of Handling on the Germ Content of Milk. N. Y. (Geneva) Agr. Exp. Sta. Bul. 317. 1909.

Harding, H. A., Wilson, J. K., and Smith, G. A. The Modern Milk Pail. N. Y. (Geneva) Agr. Exp. Sta. Bul. 326. 1910.

Harding, H. A., Ruehle, G. L., Wilson, J. K., and Smith, G. A. The Effect of Certain Dairy Operations upon the Germ Content of Milk. N. Y. (Geneva) Agr. Exp. Sta. Bul. 365, pp. 198-233. 1913.

Harding, H. A., and Wilson, J. K. A Study of the Udder Flora of Cows. N. Y. (Geneva) Agr. Exp. Sta. Tech. Bul. 27. 1913.

Ruehle, G. L. A., and Kulp, W. L. Germ Content of Stable Air and Its Effect upon the Germ Content of Milk. N. Y. (Geneva) Agr. Exp. Sta. Bul. 409, pp. 418-474. 1915.

[2]Prucha, M. J., and Weeter, H. M. Germ Content of Milk: I. As Influenced by Factors at the Barn. Ill. Agr. Exp. Sta. Bul. 199. 1917.

PREVIOUS STUDIES ON UTENSILS

In 1889, H. W. Conn[1] made the following comment on the influence of utensils upon bacterial contamination of milk: "Vessels in which milk and cream are to be kept are a great source of contamination of bacteria. The latter gather upon the sides and in the joints and develop in the minute portions of milk, grease, and other matter from which it is difficult to free the vessels completely by washing."

Five years later H. L. Russell,[2] in his studies on milk contamination, examined two covered pails. One pail was steamed for half an hour and the other was cleaned in the ordinary way but not steamed. The milk received into the sterilized pail had a germ content of 165 bacteria per cubic centimeter, while that received into the pail not steamed contained 4,265 bacteria per cubic centimeter. In commenting later on the contamination of milk by utensils, this author[3] states that "dirty vessels are a prolific source of trouble."

In 1898, Backhaus and Cronheim[4] observed that passing milk over a certain cooler raised its germ content from 11,500 to 33,000 bacteria per cubic centimeter. In 1904, Bergey[5] concluded from his studies on milk contamination that the greater portion of the bacteria with which milk becomes contaminated is derived from the utensils. In the following year, Erf and Melick[6] reported that cream separators flushed with hot water at night after being used, when used the following morning added to the germ content of the milk passing thru them, some millions of bacteria per cubic centimeter of milk. In 1906, Stewart[7] reported that the utensils invariably harbor a considerable number of bacteria. He found that it is difficult to free the utensils from germ life short of treatment with steam under pressure.

Russell and Hoffmann[8] found that when milk bottles were washed and steamed and allowed to stand twenty-four hours, the bacteria multiplied in the remnants of water resulting from the condensation of the steam.

---

[1]Conn, H. W. Bacteria in Milk and Its Products. Storrs Agr. Exp. Sta. Bul. 4. 1889.

[2]Russell, H. L. Sources of Bacterial Infection and the Relation of the Same to the Keeping Quality of Milk. Wis. Agr. Exp. Sta. Ann. Rpt. 11, p. 152. 1894.

[3]Russell, H. L. Tainted and Defective Milks: Their Causes and Methods of Prevention. Wis. Agr. Exp. Sta. Bul. 62. 1897.

[4]Backhaus, W., und Cronheim, W. Über aseptische Milchgewinnung. Ber Landw. Inst. Univ. Königbs., 1, Heft. 2, pp. 12-32. 1898.

[5]Bergey, D. H. Sources and Nature of Bacteria in Milk. Penn. Dept. of Agr. Bul. 125. 1904.

[6]Erf, O., and Melick, Chas. W. Care of Dairy Utensils. Kans. Agr. Exp. Sta. Bul. 131. 1905.

[7]Stewart, A. H. Cleansing of Milk Vessels: Relative Value of Washing Powders. Amer. Med., 2, pp. 241-244. 1906.

[8]Russell, H. L., and Hoffmann, Conrad. Bacteriological Test of Bottle-Washing Device. Wis. Agr. Exp. Sta. Ann. Rpt. 22, pp. 227-231. 1905.

The various studies upon the milking machines by Harrison,[1] by Hastings and Hoffmann,[2] Stocking and Mason,[3] Meeker,[4] and Harding, Wilson, and Smith[5] have shown that the germ content of milk may be astonishingly increased thru the influence of the milking machine, tho it is possible to keep the influence of the machine within fair limits provided it is properly handled.

METHODS OF STUDY

Washing of Utensils.—The cans used in this study were from two different dairies. In both dairies the method of washing was similar in that each can was placed in a vat containing one-percent warm solution of sodium-carbonate washing powder, and scrubbed with a brush. There were, however, some differences in the conditions and in the methods employed in the two dairies. In Dairy A the milk handled in the cans had usually a low germ content; the number of cans washed in the same lot of wash water was from 20 to 30; the amount of wash water used was 60 gallons, and the cans were rinsed after being washed. In Dairy B the milk handled in the cans invariably had a high germ content; from 60 to 80 cans were washed in the same lot of wash water; the amount of the water used was about 25 gallons, and the cans were not rinsed after they were washed.

All other utensils studied were washed in Dairy A. In the case of some of the utensils, such as the bottle filler, the above method of washing could not be employed; and in some of the experiments with cans, the method of washing was intentionally altered. Such changes are described in connection with the respective experiments.

The cans in Dairy A were of eight-gallon capacity; those in Dairy B were of five-, eight-, or ten-gallon capacity; and the bottles were the regular quart size.

Determining Number of Bacteria in Utensils.—Two methods were used in this study for determining the number of bacteria in the utensils. In the experiments reported in Part I a given quantity of sterile water, usually one liter, was poured into the utensil and after a thoro shaking, a sample of this water was taken and the number of bacteria

[1]Harrison, F. C. Machine Drawn Versus Hand Drawn Milk. Centbl. Bakt. (etc.), 2 Abt., 5, 183-189. 1899.

[2]Hastings, E. G., and Hoffmann, Conrad. Bacterial Content of Machine Drawn and Hand Drawn Milk. Wis. Agr. Exp. Sta. Ann. Rpt. 24, pp. 214-223. 1907.

[3]Stocking, W. A., Jr., and Mason, C. J. Milking Machines: Part I. Effect upon Quality of Milk. Storrs Agr. Exp. Sta. Bul. 47. 1907.

[4]Meeker, E. B. Bacterial Efficiency of the Milking Machine. Penn. Agr. Exp. Sta. Ann. Rpt. for the year 1907-1908, Part II. pp. 146-159. 1908.

[5]Harding, H. A., Wilson J. K., and Smith, G. A. Milking Machines: Effect of Method of Handling on the Germ Content of Milk. N. Y. (Geneva) Agr. Exp. Sta. Bul. 317. 1909.

in it determined. This obviously falls considerably short of demonstrating the full amount of germ life present in the utensils. In the experiments reported under Part II, samples were taken of the milk after it was actually poured into the utensils in the ordinary operations of the dairy, and the difference in the germ content of the milk handled in steamed utensils and that handled in unsteamed utensils was taken as the measure of the germ content of the unsteamed utensils. This method evidently more closely measures the true influence of the utensils upon the milk, but it is ordinarily a more difficult and expensive form of experimentation.

The plate method was used for counting the bacteria in these samples. Usually two or three dilutions were made from each sample, and three plates were poured from each dilution. Every count recorded in this study is an average of the counts from at least three plates. The medium used in making these counts had the following composition:

Agar shreds	15 grams
Liebig's meat extract	3 grams
Witte's peptone	10 grams
Lactose	10 grams
Distilled water	1 liter

The reaction of this medium was adjusted to one percent normal acid to phenolphthalein. The plates were incubated seven days: five days at 20° C. and two days at 37° C.

It should be understood that this method of counting the bacteria does not show the total number present. It was used because among the available methods of making such determinations this one seemed best suited to the problem.

PART I.—INFLUENCE SHOWN BY DIRECT EXAMINATION OF UTENSILS

Six experiments are recorded in this part of the study, five of them devoted to cans and one to bottles. The aim in these experiments was, first, to determine the number of bacteria in freshly washed but unsteamed cans and bottles; second, to determine whether bacteria increase in utensils that are washed and then kept for a period of time before being filled with milk; and third, to determine the source of these bacteria.

BACTERIA FOUND IN FRESHLY WASHED CANS

This experiment included a study of 170 cans that had been used in shipping sweet milk from the farm to the dairy. The cans reported upon in Tables 1, 2, and 3 came to Dairy A from three different farms, and those in Table 4 came to Dairy B from thirty-four different farms. In both dairies the cans were washed immediately after the milk was poured from them. The methods of washing followed in these two dairies and the method of determining the germ life remaining in the cans have already been described (page 219). The length of time intervening between the washing of the cans and the plating of the water with which they were rinsed varied from one-half to four hours.

That such rinsing did not remove all the bacteria from the utensils is self evident. In this experiment, therefore, an attempt was also made to determine approximately the accuracy of the method. For this purpose each can in Tables 1, 2, and 3 was rinsed more than once, and the relation between the number of bacteria removed by the first rinsing and that removed by subsequent rinsings was calculated. The cans in Table 1 were rinsed twice with 1,000 and 1,500 cc. of sterile water, respectively; those in Table 2 were rinsed four times with successive one-liter portions of sterile water; those in Table 3 were rinsed four times with successive two-liter portions of sterile water; and those in Table 4 were rinsed once with one liter of sterile water.

Calculations are also presented which show what the increase in the germ content of milk would have been had the total number of bacteria removed from each can been added to a can of milk.

The results of this experiment are significant in that the numbers of bacteria removed from the washed cans by rinsing them with a small quantity of sterile water were large and variable. More than one billion bacteria were removed from each of 39 of the 114 cans washed in Dairy A, and from each of 38 others the number was more than one hundred million. Even larger numbers were removed from the 56 cans washed in Dairy B; in which dairy, it will be recalled, the

milk as it was received had a higher germ content than that received at Dairy A, a greater number of cans were washed in a smaller amount of water, and the cans were not rinsed after being washed. More than one billion bacteria were removed from each of 42 of the cans in this dairy, and in only 4 cans was the number smaller than one hundred million. The largest number removed from a single can in either dairy was 96,666,000,000, and the smallest was 5,981,000.

The influence of such large numbers of bacteria on the milk may be estimated approximately by calculating the increase in the germ content of a can of milk if these numbers were added to it. The two above cans with the maximum and minimum numbers were of ten- and eight-gallon capacity, respectively. If the minimum number, 5,981,-000 bacteria, were added to eight gallons of milk, its germ content

TABLE 1.—NUMBER OF BACTERIA IN FRESHLY WASHED CANS, AS DETERMINED BY TWO SUCCESSIVE RINSINGS: DAIRY A

No. of can	Number of bacteria removed by each rinsing		Total number of bacteria removed	Increase in germ content of can of milk, per cc.	Percentage of bacteria removed by 1st rinsing
	Rinsed with 1,000 cc. of sterile water	Rinsed with 1,500 cc. of sterile water			
1	16 400 000	547 000	16 947 000	559	97
2	16 560 000	530 000	17 090 000	564	97
3	38 840 000	3 370 000	42 210 000	1 394	92
4	14 570 000	680 000	15 250 000	503	96
5	229 750 000	11 320 000	241 070 000	7 960	95
6	312 300 000	33 500 000	345 800 000	11 425	90
7	9 157 000 000	810 000 000	9 967 000 000	329 100	92
8	603 400 000	122 000 000	725 400 000	23 950	83
9	61 000 000	1 500 000	62 500 000	2 064	98
10	61 360 000	1 550 000	62 910 000	2 097	98
11	13 000 000 000	1 877 000 000	14 877 000 000	491 300	87
12	681 400 000	308 600 000	990 000 000	32 700	69
13	16 040 000	812 000	16 852 000	556	95
14	50 470 000	2 412 000	52 882 000	1 746	95
15	168 800 000	30 000 000	198 800 000	6 564	85
16	83 560 000	19 500 000	103 060 000	3 404	81
17	20 580 000 000	3 150 000 000	23 730 000 000	783 600	87
18	40 280 000	12 075 000	52 355 000	1 729	77
19	20 940 000	1 102 000	22 042 000	727	95
20	52 000 000	2 467 000	54 467 000	1 799	95
21	3 986 500 000	317 000 000	4 303 500 000	142 150	93
22	4 898 000 000	485 000 000	5 383 000 000	177 750	91
23	1 212 000 000	57 700 000	1 269 700 000	41 930	95
24	4 302 000 000	362 000 000	4 664 000 000	154 000	92
25	2 413 000 000	213 000 000	2 626 009 000	86 720	92
26	5 324 000 000	370 000 000	5 694 000 000	188 000	94
27	145 950 000	30 775 000	176 725 000	5 836	83
28	104 500 000	60 200 000	164 700 000	5 439	63
29	7 631 000 000	1 120 000 000	8 751 000 000	289 000	87
30	80 640 000	11 125 000	91 765 000	3 030	88
31	123 500 000	58 750 000	182 250 000	6 018	68
32	33 290 000	3 130 000	36 420 000	1 202	91

TABLE 2.—NUMBER OF BACTERIA IN FRESHLY WASHED CANS, AS DETERMINED BY FOUR SUCCESSIVE RINSINGS WITH ONE LITER OF STERILE WATER: DAIRY A

No. of can	Number of bacteria removed by—				Total number of bacteria removed	Increase in germ content of can of milk, per cc.	Percentage of bacteria removed by 1st rinsing
	1st rinsing	2d rinsing	3d rinsing	4th rinsing			
1	339 633 000	61 767 000	33 133 000	21 119 000	455 652 000	15 048	75
2	10 466 000	1 271 000	589 000	282 000	12 608 000	416	83
3	796 499 000	190 299 000	143 299 000	60 826 000	1 190 923 000	39 324	67
4	34 733 000	6 433 000	2 378 000	160 000	43 704 000	1 443	79
5	11 366 000	959 000	244 000	161 000	12 730 000	420	89
6	19 433 000	893 000	999 000	173 000	21 498 000	709	90
7	16 700 000	1 360 000	618 000	411 000	19 089 000	630	87
8	514 500 000	243 300 000	157 660 000	61 000 000	976 460 000	32 245	53
9	20 850 000	1 520 000	259 000	185 000	22 814 000	753	91
10	427 850 000	60 000 000	25 830 000	19 466 000	533 146 000	17 600	80
11	2 863 333 000	701 716 000	436 000 000	37 666 000	4 038 715 000	133 370	71
12	95 000 000	5 500 000	1 700 000	1 266 000	103 496 000	3 418	92
13	29 233 000	6 096 000	2 919 000	1 932 000	40 180 000	1 326	73
14	6 549 333 000	633 088 000	489 166 000	302 213 000	7 973 800 000	263 300	82
15	64 400 000	11 300 000	6 338 000	3 200 000	85 238 000	2 814	78
16	86 150 000	22 400 000	10 900 000	6 516 000	125 966 000	4 159	68
17	2 800 000	1 800 000	989 000	382 000	5 981 000	197	47
18	18 800 000	3 190 000	2 541 000	1 246 000	25 777 000	851	73
19	2 370 000 000	1 216 000 000	706 100 000	44 244 000	4 336 344 000	143 170	55
20	668 000 000	199 600 000	95 150 000	50 600 000	1 013 350 000	33 450	66
21	88 000 000	15 150 000	5 890 000	1 244 000	110 284 000	3 639	80
22	175 000 000	26 900 000	18 560 000	14 195 000	234 655 000	7 747	75
23	368 000 000	83 000 000	49 200 000	27 900 000	528 100 000	17 430	70
24	3 620 000 000	890 000 000	352 300 000	20 200 000	4 882 500 000	161 200	74
25	2 170 000 000	416 000 000	304 600 000	342 930 000	3 233 530 000	106 800	67
26	1 610 000 000	171 000 000	82 000 000	37 000 000	1 900 000 000	62 740	85
27	97 450 000	9 475 000	10 870 000	5 570 000	123 365 000	4 075	79
28	20 133 000 000	2 843 000 000	886 600 000	895 000 000	27 757 000 000	916 600	73
29	403 500 000	59 850 000	52 800 000	27 900 000	544 050 000	17 965	74
30	3 590 000 000	715 000 000	174 700 000	150 100 000	4 629 800 000	152 990	78
31	525 500 000	51 500 000	28 400 000	22 100 000	627 500 000	20 740	84
32	159 500 000	14 100 000	5 120 000	3 040 000	181 760 000	6 002	88
33	222 000 000	14 400 000	6 825 000	3 800 000	247 025 000	8 156	90
34	7 650 000 000	2 720 000 000	314 200 000	410 700 000	11 094 900 000	366 400	69
35	1 330 000 000	134 350 000	49 700 000	39 800 000	1 553 850 000	51 320	86
36	1 557 000 000	125 500 000	91 900 000	39 933 000	1 814 333 000	59 900	86
37	222 000 000	15 000 000	6 485 000	3 700 000	247 185 000	8 161	90
38	32 930 000 000	918 000 000	377 300 000	36 888 000	34 262 180 000	1 131 000	96
39	109 333 000	98 667 000	61 600 000	57 533 000	327 133 000	10 800	33
40	561 333 000	171 667 000	73 400 000	554 000	806 954 000	26 710	69
41	78 133 000	23 983 000	11 750 000	6 010 000	119 876 000	3 958	65
42	2 150 667 000	431 333 000	201 000 000	125 000 000	2 908 000 000	96 040	74
43	154 000 000	78 867 000	43 467 000	28 866 000	305 200 000	10 080	51
44	216 000 000	70 667 000	19 633 000	21 007 000	327 367 000	10 810	66
45	528 666 000	47 044 000	28 367 000	29 833 000	633 910 000	20 930	83
46	350 000 000	77 933 000	35 000 000	30 733 000	493 666 000	16 300	71
47	1 036 667 000	286 667 000	119 600 000	84 133 000	1 427 007 000	47 120	73
48	1 710 000 000	612 007 000	219 033 000	180 750 000	2 722 450 000	89 800	63
49	1 935 333 000	461 333 000	209 533 000	158 667 000	2 764 866 000	91 300	70
50	2 720 000 000	756 000 000	213 200 000	272 000 000	3 961 200 000	130 800	69

would be increased by 197 bacteria per cubic centimeter. If 96,666,-000,000 bacteria, the maximum number found in a single can, were added to ten gallons of milk, its germ content would be increased by 2,557,000 bacteria per cubic centimeter. If all the bacteria removed from the 32 eight-gallon cans listed in Table 1 were added to 256 gallons of milk (the total capacity of the cans), its germ content would be increased by 87,657 bacteria per cubic centimeter. Corresponding calculations for Tables 2, 3, and 4 would show an average increase in the germ content of the milk, of 87,059, 47,863, and 291,790 bacteria, respectively.

Of the 170 cans recorded in these tables, 54, or 31.8 percent, would have added more than 100,000 bacteria per cubic centimeter of milk;

TABLE 3.—NUMBER OF BACTERIA IN FRESHLY WASHED CANS, AS DETERMINED BY FOUR SUCCESSIVE RINSINGS WITH TWO LITERS OF STERILE WATER: DAIRY A

No. of can	Number of bacteria removed by—				Total number of bacteria removed	Increase in germ content of can of milk, per cc.	Percentage of bacteria removed by 1st rinsing
	1st rinsing	2d rinsing	3d rinsing	4th rinsing			
1	35 334 000	2 466 000	1 466 000	1 066 000	40 332 000	1 331	87
2	122 666 000	18 866 000	17 000 000	12 068 000	170 600 000	5 634	72
3	374 666 000	192 666 000	109 334 000	104 666 000	781 332 000	25 800	48
4	300 000 000	87 000 000	33 466 000	33 614 000	454 200 000	14 990	66
5	28 666 000	4 666 000	2 666 000	1 066 000	37 064 000	1 224	77
6	5 146 666 000	1 888 000 000	1 237 334 000	858 666 000	9 130 666 000	301 500	56
7	40 666 000	1 134 000	600 000	334 000	42 534 000	1 404	95
8	111 000 000	13 666 000	7 868 000	4 634 000	137 168 000	4 530	81
9	25 334 000	2 400 000	934 000	932 000	39 600 000	1 307	85
10	37 666 000	5 000 000	2 000 000	1 800 000	45 466 000	1 502	80
11	1 746 666 000	320 000 000	233 334 000	148 666 000	2 448 666 000	80 840	71
12	1 016 666 000	238 666 000	263 334 000	138 968 000	1 657 634 000	54 720	61
13	594 666 000	282 000 000	179 600 000	151 066 000	1 207 332 000	39 880	49
14	80 666 000	8 200 000	2 866 000	2 068 000	93 800 000	3 098	86
15	54 666 000	1 200 000	1 532 000	466 000	57 864 000	1 910	94
16	5 310 000 000	997 000 000	536 000 000	414 666 000	7 357 666 000	242 960	73
17	46 000 000	2 934 000	600 000	532 000	50 066 000	1 652	92
18	234 000 000	4 414 000	3 800 000	934 000	293 268 000	9 685	96
19	4 320 000 000	714 000 000	582 000 000	351 334 000	5 977 334 000	197 080	72
20	13 334 000	1 800 000	1 266 000	400 000	16 800 000	554	79
21	42 666 000	2 344 000	724 000	466 000	46 200 000	1 524	92
22	78 000 000	7 866 000	3 266 000	2 334 000	91 466 000	3 020	85
23	3 186 666 000	574 000 000	466 000 000	354 000 000	4 780 666 000	157 840	71
24	78 666 000	6 800 000	4 400 000	2 734 000	92 600 000	3 058	85
25	2 500 000 000	462 666 000	327 000 000	194 000 000	3 483 666 000	115 020	72
26	766 666 000	186 000 000	204 134 000	45 600 000	1 203 000 000	39 740	64
27	55 000 000	4 534 000	2 134 000	2 400 000	64 068 000	2 116	86
28	322 666 000	41 334 000	18 000 000	20 066 000	402 066 000	13 274	80
29	637 000 000	128 814 000	64 034 000	58 168 000	888 136 000	29 320	72
30	170 666 000	8 400 000	10 600 000	3 600 000	193 266 000	6 384	88
31	78 666 000	7 066 000	1 800 000	1 800 000	89 332 000	2 950	88
32	3 226 666 000	928 666 000	575 334 000	293 334 000	5 004 000 000	165 220	64

54 would have added more than 10,000 and less than 100,000 bacteria; and 62 cans, or 36.4 percent, would have added less than 10,000.

The data in Tables 1, 2, and 3 demonstrate that when milk cans are rinsed more than once, the first rinsing always removes a larger number of bacteria than any subsequent single rinsing. When four rinsings were made in succession, in 78 out of 82 cases the first rinsing alone removed more bacteria than all three subsequent rinsings. The data also indicate, with only fifteen exceptions, that any one of the consecutive rinsings of a can removes more bacteria than any subsequent rinsing.

If the total number of bacteria removed from each can by all the rinsings is taken as 100 percent, the calculations will show that from 110 of the 114 cans the first rinsing removed more than 50 percent of the bacteria. The highest percentage removed by the first rinsing was 97, and the lowest was 33. The average percentage removed by the first rinsing of the cans rinsed only twice, once with 1,000 cc. and once with 1,500 cc. of water (Table 1), was 89; for the cans rinsed

TABLE 4.—NUMBER OF BACTERIA IN FRESHLY WASHED CANS, AS DETERMINED BY ONE RINSING WITH ONE LITER OF STERILE WATER: DAIRY B

No. of can	Capacity, gal.	Number of bacteria removed by rinsing	Increase in germ content of can of milk, per cc.	No. of can	Capacity, gal.	Number of bacteria removed by rinsing	Increase in germ content of can of milk, per cc.
1	5	7 360 000 000	389 400	29	10	7 133 000 000	188 700
2	8	1 960 000 000	64 730	30	5	30 000 000 000	1 587 300
3	8	490 000 000	16 180	31	10	17 466 000 000	462 080
4	10	3 680 000 000	97 350	32	5	1 853 000 000	98 040
5	5	1 430 000 000	75 660	33	10	96 666 000 000	2 557 000
6	8	1 390 000 000	45 900	34	8	886 000 000	29 260
7	8	1 590 000 000	52 500	35	5	4 366 000 000	231 000
8	5	5 690 000 000	301 050	36	5	806 000 000	42 640
9	5	222 000 000	11 740	37	8	60 000 000	1 981
10	8	2 310 000 000	76 290	38	5	90 000 000	4 760
11	8	2 940 000 000	97 100	39	8	2 240 000 000	73 970
12	8	11 070 000 000	353 360	40	5	2 486 000 000	131 540
13	10	8 550 000 000	226 180	41	8	8 883 000 000	293 360
14	8	38 670 000 000	1 277 000	42	8	190 000 000	62 740
15	8	8 730 000 000	288 300	43	5	1 500 000 000	79 360
16	5	1 596 000 000	84 450	44	5	2 690 000 000	142 330
17	10	330 000 000	8 730	45	8	143 000 000	4 722
18	8	7 446 000 000	245 900	46	8	2 533 000 000	83 650
19	5	8 860 000 000	468 800	47	10	14 000 000 000	370 300
20	8	8 566 000 000	282 880	48	8	6 200 000 000	204 740
21	5	736 000 000	38 940	49	5	4 186 000 000	221 480
22	5	250 000 000	13 230	50	8	18 830 000 000	621 800
23	5	256 000 000	13 540	51	10	9 133 000 000	241 600
24	5	2 560 000 000	135 450	52	8	19 666 000 000	649 400
25	5	16 360 000 000	865 600	53	10	11 233 000 000	297 150
26	5	83 000 000	4 390	54	8	66 000 000	2 179
27	5	2 106 000 000	109 000	55	8	3 100 000 000	102 370
28	5	23 660 000 000	1 251 800	56	8	3 160 000 000	104 350

four times with one liter of water (Table 2), it was 74.6; and for the cans rinsed four times with two liters of water (Table 3), it was 77.

The results of these observations on 170 cans suggest that milk cans when washed in the ordinary manner contain sufficient germ life to heavily inoculate the milk later placed in them. The results of successive rinsings with sterile water suggest that while the germ life removed by the first rinsing amounts to a considerable fraction of the germ life in the can, it is by no means the entire germ life present. Accordingly, the germ content as determined in this manner is distinctly below the true number of bacteria actually present in the utensil under investigation.

BACTERIA FOUND IN CANS THIRTY HOURS AFTER BEING WASHED

In the preceding experiment it was shown that freshly washed cans invariably harbored large numbers of bacteria. In dairy practice the utensils, however, are not commonly used for milk immediately after they are washed. This is especially true of cans in which milk is shipped from the farm to the dairy. Such cans are washed and usually steamed at the dairy; then covered with the lids and returned to the farm, where they are frequently used for milk without any further treatment. At times, one or even two days will elapse between the washing of the cans and their use.

This experiment was designed, therefore, to determine the germ life in cans at the time they would ordinarily be used. The 160 eight-gallon cans examined were washed in Dairy A. One hundred of these were steamed, while sixty were left unsteamed.

The steaming consisted of holding each can over a jet of steam at 15 pounds pressure for 25 seconds. The pressure of the steam was measured by a gage placed between the valve and the jet opening. Other experiments upon steaming cans in this manner showed that if cans so treated were filled with milk immediately afterward, they rarely added more than 2 bacteria per cubic centimeter to the milk. Fifty of the steamed cans and fifty of those not steamed were inverted on a rack with the lids off. The other fifty steamed cans and the ten not steamed were closed immediately after washing. All the cans were then kept thirty hours in a room having a humidity of 40 percent and a temperature of 60° to 70°F. The number of bacteria found in each can is shown in Table 5.

The fifty cans that were washed, steamed, and then held thirty hours uncovered and inverted on a rack were dry and free from bad odor. The number of bacteria found in them was small in all cases. Only 3 of the fifty cans had more than one million bacteria and 36 of them had less than 100,000. If the bacteria found in these fifty cans were added to 400 gallons of milk, the germ content of this

TABLE 5.—NUMBER OF BACTERIA IN STEAMED AND IN UNSTEAMED CANS HELD THIRTY HOURS AFTER TREATMENT: DAIRY A

(As determined by rinsing with one liter of sterile water)

Steamed cans held 30 hours				Unsteamed cans held 30 hours			
Uncovered and inverted on a rack		Covered with their lids		Uncovered and inverted on a rack		Covered with their lids	
No. of can	No. of bacteria	No. of can	No. of bacteria	No. of can	No. of bacteria	No. of can	No. of bacteria
1	20 000	51	10 000	101	164 000 000	151	6 910 000 000
2	20 000	52	60 000	102	148 000 000	152	5 520 000 000
3	20 000	53	66 000 000	103	6 000 000	153	4 150 000 000
4	30 000	54	6 800 000	104	170 000 000	154	4 300 000 000
5	30 000	55	3 260 000	105	190 000 000	155	6 000 000 000
6	20 000	56	15 000 000	106	17 000 000 000	156	2 100 000 000
7	40 000	57	10 600 000	107	7 300 000 000	157	1 400 000 000
8	10 000	58	11 600 000	108	44 000 000	158	6 250 000 000
9	20 000	59	21 300 000	109	3 000 000	159	1 900 000 000
10	240 000	60	220 000	110	22 000 000	160	450 000 000
11	100 000	61	60 000 000	111	10 100 000 000		
12	290 000	62	210 000	112	1 000 000		
13	700 000	63	110 000	113	135 000 000		
14	40 000	64	30 000	114	1 000 000		
15	60 000	65	213 000 000	115	303 000 000		
16	60 000	66	39 000 000	116	76 000 000		
17	600 000	67	550 000	117	8 000 000		
18	1 450 000	68	48 000 000	118	9 000 000		
19	50 000	69	14 100 000	119	94 000 000		
20	430 000	70	2 180 000	120	59 000 000		
21	90 000	71	2 260 000	121	14 000 000		
22	30 000	72	4 800 000	122	3 000 000		
23	30 000	73	210 000	123	42 000 000		
24	50 000	74	110 000 000	124	22 000 000		
25	330 000	75	14 500 000	125	278 000 000		
26	150 000	76	210 000	126	4 700 000 000		
27	90 000	77	35 500 000	127	48 000 000		
28	30 000	78	7 000 000	128	2 000 000		
29	80 000	79	1 310 000	129	10 000 000		
30	30 000	80	35 000 000	130	21 000 000		
31	30 000	81	130 000	131	8 000 000		
32	60 000	82	4 380 000	132	1 000 000		
33	50 000	83	78 000 000	133	1 000 000		
34	90 000	84	240 000	134	17 000 000		
35	60 000	85	12 500 000	135	1 000 000		
36	20 000	86	89 000 000	136	48 000 000		
37	2 720 000	87	43 000 000	137	1 000 000		
38	30 000	88	1 190 000 000	138	3 000 000		
39	120 000	89	33 000 000	139	1 000 000		
40	30 000	90	67 000 000	140	3 000 000		
41	3 700 000	91	240 000	141	2 000 000		
42	100 000	92	50 000 000	142	2 000 000		
43	50 000	93	270 000 000	143	43 000 000		
44	20 000	94	240 000	144	2 000 000		

TABLE 5.—*Concluded*

Steamed cans held 30 hours				Unsteamed cans held 30 hours			
Uncovered and inverted on a rack		Covered with their lids		Uncovered and inverted on a rack		Covered with their lids	
No. of can	No. of bacteria	No. of can	No. of bacteria	No. of can	No. of bacteria	No. of can	No. of bacteria
45	30 000	95	149 000 000	145	5 000 000		
46	40 000	96	710 000	146	2 000 000		
47	330 000	97	590 000	147	2 000 000		
48	80 000	98	16 000 000	148	3 000 000		
49	60 000	99	550 000	149	5 000 000		
50	30 000	100	22 000 000	150	170 000		
Average no. of bacteria per can	255,800		54 988 000		822 463 400		3 898 000 000
Average no. of bacteria per cc. in can of milk	8		1 816		27 164		128 730

amount of milk would be increased by 8 bacteria per cubic centimeter. Whether any bacterial growth took place in these cans during the thirty hours is not certain, but the results show that cans so treated have a negligible effect upon the germ content of milk.

The fifty cans that were washed, steamed, and then held thirty hours with the lids on, were still wet and most of them had a more or less pronounced odor. These cans had a much larger number of bacteria than those steamed, uncovered, and inverted. Only 3 of the fifty cans had less than 100,000 bacteria, and in 34 the number was over one million. If the bacteria found in these fifty eight-gallon cans were added to 400 gallons of milk, its germ content would be increased by 1,816 bacteria per cubic centimeter.

The fifty cans that were washed but not steamed and were then held thirty hours uncovered and inverted, were dry. None of the cans had a bad odor, altho most of them were not what is called "sweet smelling." The number of bacteria in them was much larger than in the cans steamed and inverted. Only one of the fifty cans had less than one million bacteria, in 24 of them the numbers of bacteria were between one million and ten millions, and 4 cans had over a billion bacteria each. If the bacteria found in all these cans were added to 400 gallons of milk, its germ content would be increased by 27,164 bacteria per cubic centimeter. It is, however, to be observed that this average number does not give an accurate idea of the condition of these cans since the total number of bacteria found in the fifty cans was 41,123,170,000, and of this number 39,100,000,000 were contributed by only 4 cans and 2,023,170,000 by the remaining 46 cans. The

germ content of milk in these 46 cans would have averaged only 1,336 bacteria per cubic centimeter. The destructive effect of the drying of the cans upon the germ life in them is evident from a comparison of these results with those obtained from the freshly washed cans reported in Tables 1, 2, and 3.

The ten cans that were washed but not steamed and then were covered and held thirty hours had in all cases a decidedly had odor and they also contained large numbers of bacteria. Nine of the ten cans showed over a billion bacteria each. If the total number of bacteria found in these ten eight-gallon cans were added to 80 gallons of milk, its germ content would have been increased by 128,730 bacteria per cubic centimeter.

It is evident from these results that pronounced bacterial growth took place in the cans that were covered and allowed to stand for thirty hours. Bacterial growth in general is conditioned by three factors: temperature, food, and moisture. All the cans in this experiment were held at the same temperature and were washed in the same dairy by the same operator, so that the principal difference between the covered and the uncovered cans was the persistance of moisture in the covered cans. These results point to the conclusion that it is very difficult to wash cans so that no bacterial food is left in them, and if the cans are then covered without being dried, and are allowed to stand for a period of time, the bacteria in them increase to large numbers.

BACTERIA FOUND IN CANS WASHED AND RETURNED TO THE FARM

This experiment was designed to measure the germ life in cans that were washed and returned to several dairy farms ready for use. In order to maintain the usual conditions in this dairy (Dairy A), no interference was made in any of the usual operations and the men doing the work were not aware of the experiment. No record could be obtained of the exact treatment of the individual cans, but in general each can was washed, rinsed, steamed over a jet, and covered with a lid. Casual observations indicated that the steaming of the cans varied from five to twenty seconds per can.

The treatment of the cans at the farms was not uniform. At times they were inverted on a rack, with lids off, and at other times they were not opened until used. The time intervening between the washing of the cans and their use varied from six to forty hours.

Just before the cans were used for milk they were rinsed with one liter of sterile water and the germ content of this water was determined. Table 6 presents the results of the examination of 91 cans.

As in the other experiments, the numbers of bacteria found in these cans were varied and in some cases large. Can 43, for example, showed 80,000 bacteria, and Can 66 showed 30,830,000,000 bacteria. Of the

TABLE 6.—NUMBER OF BACTERIA IN CANS AFTER THEY WERE WASHED AND STEAMED IN THE DAIRY AND RETURNED TO THE FARM: DAIRY A

(As determined by rinsing with one liter of sterile water)

No. of can	Number of bacteria in cans	Increase in germ content of can of milk, per cc.	No. of can	Number of bacteria in cans	Increase in germ content of can of milk, per cc.
1	56 950 000	1 880	47	133 833 000	4 420
2	636 500 000	21 020	48	47 750 000	1 577
3	388 000 000	12 870	49	149 000 000	4 920
4	1 400 000	46	50	675 000 000	22 290
5	1 400 000	46	51	10 950 000 000	361 600
6	1 505 000 000	49 700	52	995 000 000	32 860
7	107 500 000	3 555	53	83 100 000	2 744
8	4 550 000	150	54	520 000 000	17 170
9	74 750 000	2 468	55	16 720 000	552
10	42 700 000	1 387	56	168 700 000	5 570
11	26 400 000	871	57	19 570 000	646
12	21 300 000	703	58	26 500 000	875
13	11 375 000	375	59	90 640 000	2 993
14	80 650 000	2 633	60	988 000	30
15	37 000 000	1 222	61	39 900 000	1 317
16	162 025 000	5 320	62	1 187 000 000	39 190
17	37 225 000	1 229	63	1 900 000	62
18	55 075 000	1 819	64	1 949 000 000	64 340
19	82 000 000	2 708	65	581 000 000	19 200
20	24 975 000	825	66	30 830 000 000	1 018 000
21	37 325 000	1 233	67	30 280 000	1 000
22	488 000 000	16 110	68	82 900 000	2 737
23	400 000 000	13 210	69	41 025 000	1 355
24	20 500 000	677	70	68 850 000	2 273
25	36 000 000	1 187	71	51 960 000	1 716
26	102 000 000	3 368	72	62 900 000	2 077
27	22 000 000	726	73	125 350 000	4 140
28	17 000 000	561	74	56 210 000	1 856
29	2 045 000 000	67 530	75	80 030 000	2 642
30	382 000 000	12 610	76	40 000 000	1 340
31	63 500 000	2 097	77	112 700 000	3 722
32	36 000 000	1 189	78	59 050 000	1 950
33	83 000 000	2 742	79	506 700 000	16 730
34	5 500 000	187	80	79 070 000	2 611
35	4 500 000	148	81	28 820 000	951
36	354 500 000	11 700	82	1 698 000 000	56 070
37	42 000 000	1 387	83	42 730 000	1 411
38	3 270 000 000	108 000	84	351 750 000	11 611
39	200 000	7	85	17 320 000	572
40	18 766 000	620	86	46 270 000	1 527
41	22 750 000	751	87	173 750 000	5 734
42	75 166 000	2 482	88	80 060 000	2 644
43	80 000	3	89	432 000 000	14 260
44	59 425 000	1 963	90	1 015 000 000	33 530
45	85 300 000	2 817	91	6 530 000	215
46	44 716 000	1 476			

91 cans examined, 3, or 3.3 percent, showed less than one million bacteria; 57 cans, or 62.6 percent, showed between one million and one hundred million bacteria; and 31, or 34.1 percent, showed over one hundred million bacteria.

If the number of bacteria found in Can 43 were added to eight gallons of milk (the capacity of the can), the germ content of the milk would be increased by 3 bacteria per cubic centimeter; in the case of Can 66 it would be increased by 1,018,000 bacteria. If all the bacteria found in the 91 cans were added to 728 gallons of milk (the total capacity of these cans), the germ content of this milk would be increased by 23,523 bacteria per cubic centimeter.

These cans were inspected prior to the bacteriological examination and were found to be free from any dirt and in most cases dry. It is impossible to state with certainty whether they were in a better or in a worse condition than the cans used for milk on farms in general. However, from somewhat extensive inspection of cans on a large number of farms and in dairies, the authors are of the opinion that these 91 cans were cleaner and in a better condition than the average can used for milk.

SOURCES OF BACTERIA IN WASHED CANS

The results already presented show that there are large numbers of bacteria in freshly washed cans, and that in some cans the numbers are extremely large. Two of the possible sources of these large numbers of bacteria are the milk that was previously in the can and the water in which the can was washed.

Milk as the Source of the Bacteria

In this experiment samples for bacteriological study were taken from the milk of each of 153 cans. The cans were then emptied and washed and the number of bacteria in them was determined. The results of these examinations are given in Tables 7, 8, and 9.

An examination of these tables shows that the germ content of the milk in the cans, as it arrived at the dairies, was much higher in Dairy B than in Dairy A. The number of bacteria in the cans after they were emptied and washed was likewise higher in Dairy B than in Dairy A. When, however, the comparison is confined to the individual cans in the same dairy, the relation between the germ content of the milk of a given can and the number of bacteria found in the can after it was emptied and washed, is not so evident. In a few cases, as is seen especially in the results from the cans numbering 85 to 106, a certain relation does exist, but in most cases it is not discernable.

How many of the bacteria found in a given washed can came from the milk held by the can previous to washing would naturally depend on the germ content of the milk and also on the amount of the milk left in the can after it was washed. It is self evident that after the

TABLE 7.—GERM CONTENT OF MILK IN THE CANS, AND NUMBER OF BACTERIA IN THE CANS AFTER THEY WERE WASHED

(Bacteria in cans determined by rinsing with one liter of sterile water)

No. of can	Germ content of milk in cans, per cc.	No. of bacteria in the can after being washed	No. of can	Germ content of milk in cans, per cc.	No. of bacteria in the can after being washed
		Dairy A			
1	380 000	214 000 000	21	1 400	5 900 000
2	342 000	60 000 000	22	1 100	5 900 000
3	298 000	2 000 000	23	1 000	7 400 000
4	175 000	9 000 000	24	21 200	2 000 000
5	51 000	2 000 000	25	10 000	700 000
6	51 000	1 000 000	26	8 800	500 000
7	48 000	2 000 000	27	7 200	700 000
8	13 000	2 000 000	28	3 600	2 000 000
9	4 900	2 000 000	29	2 300	2 600 000
10	5 300	5 000 000	30	1 300	800 000
11	3 400	15 000 000	31	1 100	4 900 000
12	213 000	9 000 000	32	59 800	3 200 000
13	178 000	8 900 000	33	40 300	3 600 000
14	176 000	9 100 000	34	23 600	363 000 000
15	152 000	6 800 000	35	16 700	9 100 000
16	130 000	3 400 000	36	11 400	3 300 000
17	18 000	6 300 000	37	3 600	7 000 000
18	7 400	4 400 000	38	1 900	3 200 000
19	4 000	14 300 000	39	1 800	4 500 000
20	2 500	10 100 000	40	1 000	3 800 000
		Dairy B			
41	101 300 000	113 670 000 000	74	40 000	430 000 000
42	52 000 000	49 330 000 000	75	2 210 000	1 690 000 000
43	40 800 000	4 100 000 000	76	300 000	4 440 000 000
44	33 500 000	13 400 000 000	77	5 520 000	30 400 000 000
45	18 170 000	2 870 000 000	78	350 000	18 650 000 000
46	18 000 000	6 060 000 000	79	10 830 000	5 670 000 000
47	13 200 000	7 970 000 000	80	14 500 000	8 400 000 000
48	9 370 000	930 000 000	81	2 750 000	70 660 000 000
49	6 920 000	4 900 000 000	82	1 390 000	104 330 000 000
50	6 600 000	2 220 000 000	83	290 000	21 800 000 000
51	5 460 000	8 000 000 000	84	9 500 000	720 000 000
52	5 270 000	330 000 000	85	10 000	140 000 000
53	4 530 000	51 330 000 000	86	550 000	1 200 000 000
54	4 490 000	1 660 000 000	87	1 970 000	26 970 000 000
55	3 950 000	3 160 000 000	88	710 000	4 680 000 000
56	3 400 000	40 000 000 000	89	350 000	12 600 000 000
57	3 000 000	690 000 000	90	20 000	3 890 000 000
58	2 960 000	62 060 000 000	91	650 000	18 920 000 000
59	2 460 000	47 000 000 000	92	10 000	200 000 000
60	2 010 000	9 470 000 000	93	1 500 000	19 070 000 000
61	1 990 000	7 600 000 000	94	220 000	3 460 000 000
62	1 820 000	650 000 000	95	40 000	130 000 000
63	1 000 000	5 270 000 000	96	900 000	26 240 000 000
64	910 000	9 400 000 000	97	510 000	5 080 000 000
65	800 000	110 000 000	98	170 000	2 080 000 000
66	620 000	43 000 000 000	99	10 000	190 000 000
67	510 000	4 300 000 000	100	130 000	1 580 000 000
68	340 000	2 130 000 000	101	11 500 000	65 000 000 000
69	320 000	11 470 000 000	102	2 060 000	21 660 000 000
70	230 000	5 270 000 000	103	60 000	650 000 000
71	160 000	3 070 000 000	104	420 000	16 400 000 000
72	70 000	920 000 000	105	2 000 000	40 330 000 000
73	70 000	250 000 000	106	40 000	270 000 000

can is emptied and washed, the amount of the milk still adhering to the walls of the can is extremely small.

That the milk held by a can previous to washing was not the principal source of the bacteria in the washed cans in cases where the number of bacteria was large, may be shown by calculating the amount of the milk that would have been necessary to have supplied the number of bacteria found in the washed cans. Cans 65 and 66 may be taken for this calculation. These two cans were washed in succession, within one minute of each other, in the same wash water. The germ content of the milk held by Can 65 was 800,000 bacteria per cubic centimeter, and the number of bacteria in this can after it was washed was 110,000,000. It would have required 137 cc. of the milk to have supplied the number of bacteria found in the can after it was washed. The germ content of the milk in Can 66 was 620,000 bacteria per cubic centimeter, and after the can was washed the number of bacteria found in it was 43,000,000,000. In this case it would have required 69,355 cc. (about 18 gallons) of the milk to have supplied this number of bacteria.

It is seen from this experiment, therefore, that in dairies which receive milk with high germ content, the cans after being washed, and if not steamed, will have correspondingly large numbers of bacteria. On the other hand, the large numbers of bacteria in some cans after they are washed in the same dairy and in the same lot of wash water, must have some source other than the milk.

Wash Water as a Source of Bacteria

When milk is poured from a can, a small amount of it always adheres to the inner walls of the can. In the process of washing, these traces of milk are transferred to the wash water. It is evident that the germ content of the wash water may become very high if the milk was heavily seeded with bacteria, if the cans are dirty, or if a large number of cans are washed in the same lot of wash water. This experiment was therefore undertaken to determine the influence of the wash water on the number of bacteria in the washed cans.

All the cans reported in Table 8 were washed in one lot of wash water, and the same was true of those listed in Table 9. In Tables 10 and 11 a fresh lot of water was used for every set of cans, each set including from five to nine cans.

In Table 8 the wash water contained one percent of sodium-carbonate washing powder. In Table 9 the wash water contained no washing powder of any kind. In Table 10 each set of cans was washed first in one-percent washing-powder solution and, without using these cans for milk after this washing, they were washed again thirty minutes later but only in plain water. In Table 11 the cans were treated exactly as in Table 10 except that the first washing was done in plain

water and the second washing in one-percent solution of washing powder.

In Tables 8 and 9 the samples for bacteriological study were taken from the milk of each can just before the cans were emptied and washed. The samples from the wash water were taken from the vat: first, at the beginning of washing; second, at certain intervals during the washing; and third, after all the cans were washed. In Tables 10 and 11, the milk samples were omitted, and the samples from the wash water in the vat were taken at the beginning and at the end of the washing of each set of cans.

TABLE 8.—GERM CONTENT OF MILK, OF WASH WATER, AND OF WASHED CANS
(Cans washed in 25 gallons of water, *with* washing powder: Dairy B)

No. of can	Germ content of milk in cans, per cc.	Bacteria removed from washed cans by one liter of rinse water	Germ content of wash water, per cc.
Before washing			100 000
1	2 210 000	1 690 000 000	
2	300 000	4 440 000 000	
3	5 520 000	30 400 000 000	
4	350 000	18 650 000 000	
5	10 830 000	5 670 000 000	
6	14 500 000	8 400 000 000	
7	2 750 000	70 660 000 000	
8	1 390 000	104 330 000 000	
9	290 000	21 800 000 000	
10	9 500 000	720 000 000	
11	10 000	140 000 000	
12	550 000	1 200 000 000	
After 12 cans were washed			3 210 000
13	1 970 000	26 970 000 000	
14	710 000	4 680 000 000	
15	350 000	12 000 000 000	
16	20 000	3 890 000 000	
17	650 000	18 920 000 000	
18	10 000	200 000 000	
19	1 500 000	19 070 000 000	
20	220 000	3 460 000 000	
21	40 000	130 000 000	
22	900 000	26 240 000 000	
After 22 cans were washed			3 420 000
23	510 000	5 080 000 000	
24	170 000	2 080 000 000	
25	10 000	190 000 000	
26	130 000	1 580 000 000	
27	11 500 000	65 000 000 000	
28	2 060 000	21 660 000 000	
29	60 000	650 000 000	
30	420 000	16 400 000 000	
31	2 000 000	40 330 000 000	
32	40 000	270 000 000	
After 32 cans were washed			5 100 000

After each can was washed it was allowed to stand twenty to thirty minutes; then one liter of sterile water was poured in and after thoro shaking, the germ content of this water was determined. In Tables 10 and 11 each can was washed twice in succession and the number of bacteria determined after each washing.

All the cans in Tables 8 and 9, those in Table 10 numbering 21 to 43, and those in Table 11 numbering 27 to 44 came from Dairy B. The remaining cans in Tables 10 and 11 came from Dairy A. For the purpose of this experiment, however, the usual methods of washing followed in these dairies were discarded and the cans in both dairies were washed in the same way. About 25 gallons of warm water was run into the vat, and when washing powder was used, one percent of it was added to the water. Each can was placed in the water, scrubbed with a brush, and then inverted on a rack for about six seconds to drain. None of the cans in either dairy were rinsed with plain water after being washed.

The germ content of the water supply in these dairies varied from 100 to 2,000 bacteria per cubic centimeter. It will be noticed from the above tables that when the water was run into the vat preparatory to being used for washing the cans, its germ content invariably increased. For example, in Table 8 before any cans were washed in the water the germ content was 100,000 bacteria per cubic centimeter. This increase was apparently due to the bacteria present on the inner surface of the vat.

TABLE 9.—GERM CONTENT OF MILK, OF WASH WATER, AND OF WASHED CANS
(Cans washed in 25 gallons of water, *without* washing powder: Dairy B)

No. of can	Germ content of milk in cans, per cc.	Bacteria removed from washed cans by one liter of rinse water	Germ content of wash water, per cc.
Before any cans were washed			155 000
33	3 060 000	480 000 000	
34	520 000	1 900 000 000	
35	130 000	1 180 000 000	
36	1 390 000	170 000 000	
37	1 870 000	8 750 000 000	
38	105 000 000	10 970 000 000	
39	640 000	820 000 000	
40	11 600 000	710 000 000	
41	940 000	50 000 000	
After 9 cans were washed			412 000
42	80 000	720 000 000	
43	80 000	490 000 000	
44	900 000	1 170 000 000	
45	830 000	10 000 000	
46	50 000	280 000 000	
47	6 300 000	14 690 000 000	
After 15 cans were washed			457 000

TABLE 10.—GERM CONTENT OF WASH WATER AND OF CANS WASHED TWICE IN SUCCESSION; FIRST IN WASHING-POWDER SOLUTION, THEN IN PLAIN WATER

(New lot of 25 gallons of water used for every 5 to 9 cans)

No. of can	First washing—washing powder		Second washing—plain water	
	Bacteria removed from washed cans by one liter of rinse water	Germ content of wash water, per cc.	Bacteria removed from washed cans by one liter of rinse water	Germ content of wash water, per cc.
		Dairy A		
Before washing		500		15 400
1	7 000 000		500 000	
2	24 000 000		400 000	
3	17 000 000		100 000	
4	1 000 000		100 000	
5	3 000 000			
After 5 cans were washed		14 200		44 400
Before washing		28 000		5 600
6	2 000 000		400 000	
7	3 000 000		400 000	
8	3 000 000		300 000	
9	2 000 000		900 000	
10	2 000 000		600 000	
11	2 000 000		500 000	
12	2 000 000		900 000	
13	47 000 000		10 600 000	
14	2 000 000		600 000	
After 9 cans were washed		88 000		28 000
Before washing		21 800		7 500
15	500 000		490 000	
16	700 000		600 000	
17	600 000		900 000	
18	700 000		410 000	
19	1 600 000		640 000	
20	700 000		620 000	
After 6 cans were washed		40 000		47 000
		Dairy B		
Before washing		28 000		17 000
21	190 000 000		30 900 000	
22	100 000 000		20 100 000	
23	3 190 000 000		723 000 000	
24	10 400 000 000		787 000 000	
25	240 000 000		14 600 000	
After 5 cans were washed		20 000 000		1 400 000
Before washing		30 000		7 000
26	10 000 000		100 000	
27	60 000 000		2 600 000	
28	60 000 000		2 300 000	
29	160 000 000		3 800 000	
30	1 450 000 000		30 800 000	
After 5 cans were washed		670 000		110 000

TABLE 10.—*Concluded*

No. of can	First washing—washing powder: Bacteria removed from washed cans by one liter of rinse water	First washing—washing powder: Germ content of wash water, per cc.	Second washing—plain water: Bacteria removed from washed cans by one liter of rinse water	Second washing—plain water: Germ content of wash water, per cc.
Before washing		20 500		5 500
31	58 000 000		6 400 000	
32	1 023 000 000		260 000 000	
33	777 000 000		97 000 000	
34	98 000 000		25 000 000	
35	28 000 000		2 400 000	
After 5 cans were washed		400 000		140 000
Before washing		19 000		18 200
36	40 000 000		17 600 000	
37	3 000 000		1 000 000	
38	5 700 000 000		2 830 000 000	
39	753 000 000		96 600 000	
40	194 000 000		11 000 000	
41	1 153 000 000		250 000 000	
42	4 400 000 000		1 066 600 000	
43	173 000 000		10 100 000	
After 8 cans were washed		14 000 000		450 000

As the process of washing proceeded, the number of bacteria in the wash water always increased. The thirty-two cans recorded in Table 8 were washed in water containing one percent of washing powder. Before any cans were washed, the water had 100,000 bacteria per cubic centimeter. After 12 cans were washed, the germ content of the water increased to 3,210,000 bacteria; after 22 cans were washed it increased to 3,420,000; and after 32 cans were washed it became 5,100,000. The water in which the cans in Table 9 were washed contained no washing powder. Its initial germ content was 155,000 bacteria per cubic centimeter, and after 15 cans were washed in it, its germ content increased to 457,000 bacteria. Similar results were obtained in Tables 10 and 11, where a new lot of wash water was prepared for every five to nine cans. In one case the initial germ content of the wash water was 28,000 bacteria per cubic centimeter, and after 5 cans were washed, its germ content increased to 20,000,000 bacteria.

The number of bacteria added to the cans by the wash water depends naturally on the germ content of the water and also on the amount of the water left in the cans. Several trials on this point demonstrated that from 10 to 25 cc. of water adhere to the inner surface of a can.

TABLE 11.—GERM CONTENT OF WASH WATER, AND OF CANS WASHED TWICE IN SUCCESSION; FIRST IN PLAIN WATER, THEN IN WASHING-POWDER SOLUTION

(New lot of 25 gallons of water used for every 5 to 9 cans)

No. of can	First washing—plain water		Second washing—washing powder	
	Bacteria removed from washed cans by one liter of rinse water	Germ content of wash water, per cc.	Bacteria removed from washed cans by one liter of rinse water	Germ content of wash water, per cc.
		Dairy A		
Before washing		400		13 200
1	340 000 000		100 000	
2	1 000 000			
3	2 000 000		7 000 000	
4	277 000 000			
5	4 000 000		4 000 000	
After 5 cans were washed		11 800		47 600
Before washing		500		15 400
6	7 000 000		500 000	
7	24 000 000		400 000	
8	17 000 000		100 000	
9	1 000 000		100 000	
10	3 000 000			
After 5 cans were washed		14 200		44 400
Before washing		1 400		3 300
11	1 000 000		800 000	
12	7 000 000		7 000 000	
13	14 000 000		300 000	
14	3 000 000		800 000	
15	2 000 000		700 000	
16	1 000 000		1 000 000	
17	2 000 000		1 700 000	
18	5 000 000		1 300 000	
19	232 000 000		17 900 000	
After 9 cans were washed		200 000		94 000
Before washing		12 900		6 100
20	9 000 000		620 000	
21	1 000 000		580 000	
22	1 100 000		620 000	
23	1 200 000		770 000	
24	1 300 000		700 000	
25	400 000		790 000	
26	1 200 000		830 000	
After 7 cans were washed		69 000		......

TABLE 11.—*Concluded*

No. of can	First washing—plain water: Bacteria removed from washed cans by one liter of rinse water	First washing—plain water: Germ content of wash water, per cc.	Second washing—washing powder: Bacteria removed from washed cans by one liter of rinse water	Second washing—washing powder: Germ content of wash water, per cc.
		Dairy B		
Before washing		......		200
27	3 350 000 000		115 200 000	
28	970 000 000		23 700 000	
29	3 630 000 000		143 300 000	
30	140 000 000		9 600 000	
31	450 000 000		500 000	
After 5 cans were washed		4 800 000		510 000
Before washing		1 400		28 000
32	1 084 000 000		783 000 000	
33	11 000 000		2 700 000	
34	3,416 000 000		355 000 000	
35	132 000 000		82 000 000	
36	26 000 000		9 800 000	
After 5 cans were washed		1 200 000		600 000
Before washing		......		107 000
37	37 000 000		82 700 000	
38	55 000 000		66 000 000	
39	184 000 000		64 700 000	
40	748 000 000		123 300 000	
41	33 000 000		10 300 000	
42	563 000 000		100 300 000	
43	25 000 000		22 000 000	
44	47 000 000		14 800 000	
After 8 cans were washed		14 400 000		450 000

Cans 31 and 32 in Table 8 were washed in the same water within one minute of each other. In Can 31 the bacteria numbered 40,330,000,000 and in Can 32, 270,000,000. The germ content of the wash water at this point was 5,100,000 bacteria per cubic centimeter. If the number of bacteria in these two cans was due to the wash water alone, it would have required 53 cc. of the water to have supplied the number in Can 32, while in Can 31 it would have required 7,907 cc. of the water. Similar calculations for each can in these tables show that in some cans the relatively small numbers of bacteria correspond somewhat closely to the number of bacteria in the amount of the water that may adhere to them. However, in many of the cans the number is too large to be accounted for by the wash-water contamination alone. In addition, there appears to be no gradual increase in the germ content of the consecutively washed cans. This leads to the conclusion, therefore, that the exceptionally large numbers

of bacteria in the washed cans had some other source than the wash water.

In 1889 Conn stated that "bacteria gather upon the sides of the utensils and develop in the minute portions of milk, grease, and other matter from which it is difficult to free the vessels completely by washing." The data in this experiment support Conn's conclusion and further emphasize the striking capacity of the bacteria to multiply in the extremely minute portions of the milk, fat, and other matter, and to adhere to the walls of the cans. The large numbers of bacteria found in cans may be accounted for on the ground that the cans are difficult to clean thoroly, and that in the traces of this dirt numerous bacteria are imbedded and then are loosened by the washing process and subsequently removed by rinsing.

The purpose of this experiment was also to show the influence of the washing powder upon the germ content of the wash water and the washed cans. The cans listed in Table 8 were washed in water containing washing powder and those in Table 9 in plain water. Those shown in Tables 10 and 11 were washed twice in succession, half of them in washing-powder solution first and then in plain water, and half in plain water first and then in washing-powder solution. A perusal of these tables shows that the washing powder exerted no discernable influence upon the germ content of the wash water or of the washed cans. The germ content of the wash water increased during the washing process to about the same extent in the plain water and in the washing-powder solution, and many of the cans in both cases had extremely large numbers of bacteria.

It is customary in some dairies to wash a large number of utensils in the same lot of wash water, and then not to rinse them sufficiently with clean water or not to rinse them at all. Such practice results in seeding the wash water with large numbers of bacteria which were present in the dirt and in the milk that adhere to the walls of the utensils. When utensils are washed in such a manner, some may contain a larger number of bacteria after they are washed than they contained before they were washed.

Naturally the object of the washing process is to remove the dirt and the milk residues from the can, and the completeness with which it accomplishes this result is the true measure of its success. A reduction of the germ life in the can is ordinarily accomplished at the same time, but this reduction cannot be carried to satisfactory limits by the washing process without an undue expense for water, heat, and washing powder. The destruction of the germ life in the cans is ordinarily accomplished more economically and more completely by the direct application of steam.

Bacteria Found in Bottles Freshly Washed and in Bottles Standing Twenty-four Hours

The washing of milk bottles is in a measure comparable to that of cans. Like cans, the bottles are washed in the same water in large numbers. They are returned to the dairy at times in dirty condition and frequently contain traces of milk with high germ content.

In the dairy in which this experiment was conducted, it was the custom to wash from 150 to 200 bottles in a vat containing about 60 gallons of warm water to which was added 5 pounds of sodium-carbonate washing powder. The bottles were scrubbed with a steam-driven brush, and then rinsed in another vat containing about 60 gallons of tap water; they were not steamed. For the purpose of this experiment two sets of the washed bottles, nine to fourteen in each set, were selected from each of fourteen different lots for study.

In order to obtain two comparable sets of bottles, selection was made in the following manner: The first two bottles washed were taken, then the eleventh and twelfth, then the twenty-first and twenty-second, and so on until all the bottles were washed. Those having odd numbers constituted the first set and those with even numbers the second set. The bottles in the first set were examined immediately after being washed and those in the second set after they had been kept inverted twenty-four hours on a wire rack. The examination consisted in rinsing each bottle with 100 cc. of sterile water and determining the number of bacteria in the water. The results of the examination of 308 bottles are given in Table 12.

The number of bacteria found in these bottles was variable and in some cases large. Among the bottles examined immediately after washing 25, or 16.2 percent, had more than one million bacteria, and 129, or 83.8 percent, had less than one million. The largest number of bacteria found in any one bottle was 40,660,000, and the smallest was 20,000.

The bottles that were held twenty-four hours after they were washed were found to be dry and free from bad odors. Eighty-four of these, or 54.5 percent, had more than one million bacteria, and 70, or 45.5 percent, had less than one million. The largest number of bacteria found was 231,700,000, and the smallest number was 3,000.

It will be observed that some of the bottles examined immediately after they were washed had a larger number of bacteria than some of the bottles held twenty-four hours. On the average, however, there was a decided increase in the number of bacteria in the bottles which were held twenty-four hours. This is brought out more clearly by calculating the average number of bacteria per bottle on each of the different days. These averages are given in Table 13.

The averages in Table 13 show that, in all cases, the set of bottles held twenty-four hours averaged more bacteria than the corresponding

TABLE 12.—NUMBER OF BACTERIA IN BOTTLES FRESHLY WASHED AND TWENTY-FOUR HOURS LATER: DAIRY A

(As determined by rinsing each bottle with 100 cc. of sterile water)

Total number of bacteria in bottles—				Total number of bacteria in bottles—			
No. of bottle	Freshly washed	No. of bottle	24 hours after washing	No. of bottle	Freshly washed	No. of bottle	24 hours after washing
	June 20		*June 20-21*		*June 21*		*June 21-22*
1	3 800 000	2	47 000 000	25	110 000	26	3 040 000
3	6 000 000	4	68 300 000	27	110 000	28	36 500 000
5	5 200 000	6	120 000 000	29	140 000	30	61 330 000
7	4 700 000	8	123 000 000	31	110 000	32	11 800 000
9	4 300 000	10	107 000 000	33	90 000	34	48 670 000
11	4 500 000	12	15 500 000	35	120 000	36	22 330 000
13	15 000 000	14	36 000 000	37	110 000	38	29 330 000
15	7 900 000	16	231 700 000	39	490 000	40	36 330 000
17	6 100 000	18	18 700 000	41	140 000	42	68 000 000
19	11 300 000	20	64 600 000	43	40 660 000	44	72 330 000
21	8 000 000	22	27 700 000				
23	6 600 000	24	163 000 000				
	June 22		*June 22-23*		*June 23*		*June 23-24*
45	2 950 000	46	4 700 000	63	30 000	64	2 290 000
47	100 000	48	100 000	65	2 730 000	66	1 280 000
49	340 000	50	5 130 000	67	40 000	68	6 030 000
51	520 000	52	15 430 000	69	200 000	70	15 000 000
53	110 000	54	6 570 000	71	70 000	72	8 570 000
55	270 000	56	20 670 000	73	120 000	74	9 870 000
57	850 000	58	5 400 000	75	190 000	76	34 000 000
59	210 000	60	910 000	77	80 000	78	1 830 000
61	780 000	62	180 000	79	100 000	80	3 190 000
	June 26		*June 26-27*		*June 27*		*June 27-28*
81	630 000	82	360 000	101	43 000	102	30 000
83	410 000	84	30 500 000	103	315 000	104	2 700 000
85	320 000	86	430 000	105	83 000	106	480 000
87	340 000	88	300 000	107	68 000	108	210 000
89	760 000	90	30 000	109	40 000	110	10 000
91	400 000	92	120 000	111	335 000	112	470 000
93	230 000	94	170 000	113	54 000	114	160 000
95	590 000	96	140 000	115	48 000	116	10 000
97	250 000	98	350 000	117	303 000	118	1 490 000
99	220 000	100	120 000	119	71 000	120	2 020 000
	June 28		*June 28-29*		*June 30*		*June 30—July 1*
121	62 000	122	370 000	139	305 000	140	830 000
123	295 000	124	80 000	141	243 000	142	1 920 000
125	175 000	126	140 000	143	279 000	144	10 000
127	901 000	128	230 000	145	30 000	146	750 000
129	170 000	130	100 000	147	600 000	148	2 070 000
131	220 000	132	15 160 000	149	61 000	150	630 000
133	333 000	134	80 000	151	2 430 000	152	470 000
135	5 733 000	136	1 500 000	153	93 000	154	250 000
137	1 130 000	138	90 000	155	41 000	156	320 000
				157	61 000	158	260 000

TABLE 12.—*Concluded*

Total number of bacteria in bottles—				Total number of bacteria in bottles—			
No. of bottle	Freshly washed	No. of bottle	24 hours after washing	No. of bottle	Freshly washed	No. of bottle	24 hours after washing
	Sept. 25, a. m.		*Sept. 25-26, a. m.*		*Sept. 25, p. m.*		*Sept. 25-26, p. m.*
159	450 000	160	90 000	183	43 000	184	13 330 000
161	36 000	162	3 000	185	46 000	186	1 926 000
163	40 000	164	3 090 000	187	66 000	188	2 826 000
165	26 000	166	853 000	189	36 000	190	3 026 000
167	50 000	168	3 000	191	66 000	192	310 000
169	50 000	170	250 000	193	43 000	194	310 000
171	63 000	172	43 000	195	33 000	196	930 000
173	36 000	174	660 000	197	50 000	198	350 000
175	40 000	176	76 000	199	30 000	200	630 000
177	53 000	178	396 000	201	740 000	202	316 000
179	66 000	180	1 300 000	203	66 000	204	2 773 000
181	20 000	182	206 000	205	80 000	206	150 000
	Sept. 27, a. m.		*Sept. 27-28, a. m.*		*Sept. 27, p. m.*		*Sept. 27-28, p. m.*
207	83 000	208	4 880 000	231	340 000	232	4 560 000
209	593 000	210	4 800 000	233	350 000	234	3 746 000
211	90 000	212	110 000	235	540 000	236	5 300 000
213	276 000	214	4 226 000	237	396 000	238	11 400 000
215	276 000	216	4 073 000	239	1 553 000	240	6 933 000
217	283 000	218	8 600 000	241	300 000	242	1 753 000
219	110 000	220	313 000	243	740 000	244	3 700 000
221	100 000	222	320 000	245	540 000	246	2 950 000
223	163 000	224	13 000	247	370 000	248	13 660 000
225	2 493 000	226	3 396 000	249	660 000	250	10 300 000
227	363 000	228	6 000	251	1 043 000	252	1 336 000
229	570 000	230	660 000	253	1 090 000	254	12 330 000
	Sept. 29, a. m.		*Sept. 29-30, a. m.*		*Oct. 2, p. m.*		*Oct. 2-3, p.m.*
255	6 986 000	256	6 400 000	285	73 000	286	50 000
257	280 000	258	9 530 000	287	57 000	288	10 000
259	3 160 000	260	2 670 000	289	99 000	290	60 000
261	450 000	262	2 100 000	291	77 000	292	10 720 000
263	340 000	264	6 020 000	293	165 000	294	80 000
265	436 000	266	3 995 000	295	237 000	296	30 000
267	230 000	268	2 600 000	297	63 000	298	110 000
269	513 000	270	4 606 000	299	46 000	300	10 000
271	253 000	272	3 853 000	301	44 000	302	2 020 000
273	8 700 000	274	4 253 000	303	56 000	304	270 000
275	350 000	276	3 366 000	305	74 000	306	260 000
277	286 000	278	1 963 000	307	64 000	308	110 000
279	400 000	280	60 000				
281	386 000	282	3 000				
283	296 000	284	26 000				

set of the same day examined immediately after the washing. The average number of bacteria in all the 154 bottles examined immediately after the washing was 1,271,950 per bottle, and in those held twenty-four hours it was 12,283,490 per bottle.

One quart is approximately 950 cubic centimeters; so that if these bottles had been filled with milk, the germ content of the milk would have been increased, on the average, by 1,339 bacteria per cubic centimeter by the freshly washed bottles and 12,930 bacteria per cubic centimeter by the bottles held twenty-four hours after the washing. From these results it is evident that bottles washed but not steamed may have an appreciable effect upon the germ content of milk, especially when they are held for some hours before being filled.

TABLE 13.—AVERAGE NUMBER OF BACTERIA IN WASHED BOTTLES

Date, 1916	Number of bottles	Bottles freshly washed	Bottles held 24 hours after washing
June			
20	12	6 950 000	85 200 000
21	10	4 208 000	38 966 000
22	9	681 000	6 565 000
23	9	395 000	9 115 000
26	10	415 000	3 252 000
27	10	136 000	758 000
28	9	1 002 000	1 970 000
30	10	414 000	751 000
Sept.			
25 a.m.	12	78 000	581 000
25 p.m.	12	108 000	2 240 000
27 a.m.	12	450 000	2 616 000
27 p.m.	12	660 000	6 497 000
29 a.m.	15	1 538 000	3 429 000
Oct.			
2. p.m.	12	879 000	1 144 000
Average number of bacteria in 154 bottles......		1 271 950	12 283 490

PART II.—INFLUENCE SHOWN BY EXAMINATION OF THE MILK

The four experiments reported in this part were designed to ascertain the influence of the various unsteamed utensils upon the germ content of milk, in actual dairy operations. This influence was measured by the difference in the germ content of milk handled in steamed and in unsteamed utensils.

The utensils were washed as described on page 219. The steaming consisted in holding the utensils in a chamber filled with flowing steam, for about an hour, with the exception that some of the pails and cans were held over a jet of steam for two to three minutes. The thoroness of the steaming of the utensils was always tested bacteriologically and found to be satisfactory.

Collective Influence of Utensils at the Barn

This experiment was designed to measure the collective influence on the germ content of milk of unsteamed pails, strainers, and cans used at three dairy barns. In each barn the milk was drawn into small-topped pails and strained thru a combination cloth and wire strainer into eight-gallon cans. After each milking, the utensils were washed in water containing washing powder, rinsed in a vat of tap water, and placed on a rack. At each milking a new strainer cloth was used. The utensils were used, as a rule, in from six to twelve hours after being washed, altho in a few cases cans were held twenty-four to thirty-six hours.

Normally, the utensils were steamed after being washed at these dairy farms; but in order to bring out the influence of unsteamed utensils, the steaming was omitted on some days. The samples of milk were removed from the cans for bacteriological examination within one hour after milking, both when the utensils had been steamed and when they had been left unsteamed. The results of bacteriological examination are given in Tables 14 to 19.

These tables present a striking contrast between the germ content of milk handled in steamed utensils and that handled in unsteamed utensils. When the pails, the strainers, and the cans were steamed, only 4 cans of milk out of 34 in Barn I, and 3 out of 35 in Barn II had a germ content above 10,000 bacteria per cubic centimeter. The average germ content for all the milk handled in steamed utensils was 4,865 bacteria per cubic centimeter in Barn I and 3,157 in Barn II. The results from Barn III were somewhat higher, the average germ content being 12,400 per cubic centimeter for steamed utensils.

On the other hand, when the utensils were not steamed, the germ content of the milk became higher and more variable. Of the 117 cans

of milk from the three barns, 7 had more than one million bacteria per cubic centimeter, 81 had above 100,000, and only 2 had less than 10,000. The highest germ content in a single can was 2,623,100 and the lowest was 7,100. The average germ content for all the milk handled in unsteamed utensils was 311,000 for Barn I, 326,880 for Barn II, and 218,930 for Barn III.

The bacteria that were found in the milk in these cans were contributed by all the sources of contamination to which the milk was exposed on its way from the udder to the cans. The difference between the germ content of the milk handled in the steamed utensils and that

TABLE 14.—GERM CONTENT OF MILK HANDLED IN STEAMED PAILS, STRAINERS, AND CANS: BARN I

No. of can	Oct. 3, 1914, a.m.	Oct. 4, a.m.	May 12, 1915, a.m.	May 13, a.m.	May 21, a.m.	May 22, a.m.	May 25, a.m.
	Number of bacteria per cc. of milk in cans						
1	1 904	1 690	6 805	3 617	15 522	12 075	826
2	2 486	1 267	5 727	3 482	6 200	1 170	2 600
3	3 280	....	5 542	3 032	4 950	5 285	3 592
4	2 502	....	7 290	1 660	8 885	3 952	10 510
5	....	....	10 720	3 500	....	4 997	2 712
6	....	....	.....	....	....	4 652	5 837
7	....	....	.....	....	....	2 555	4 600

TABLE 15.—GERM CONTENT OF MILK HANDLED IN UNSTEAMED PAILS, STRAINERS, AND CANS: BARN I

No. of can	May 3, 1915, p.m.	May 4, a.m.	May 5, p.m.	May 6, a.m.	May 6, p.m.	May 7, a.m.
	Number of bacteria per cc. of milk in cans					
1	78 700	38 400	624 500	887 500	108 000	120 000
2	.....	45 600	......	763 100	779 000	39 100
3	.....	130 500	......	57 100	......	23 200
4	.....	7 100	......	18 200	......	30 200
5	.....	28 800	......	2 623 100	......	31 200
6	.....	.....	......	9 200	......	90 400

TABLE 16.—GERM CONTENT OF MILK HANDLED IN STEAMED PAILS, STRAINERS, AND CANS: BARN II

No. of can	Oct. 3, 1914, a.m.	May 12, 1915, a.m.	May 12, p.m.	May 13, a.m.	June 1, p.m.	June 3, p.m.
	Number of bacteria per cc. of milk in cans					
1	785	5 960	850	1 605	6 507	1 237
2	610	1 500	1 985	1 820	1 297	942
3	837	2 187	1 616	2 077	11 837	785
4	235	19 400	1 722	1 040	4 515	1 205
5	770	886	1 977	6 015	4 692	1 777
6	...	....	4 027	2 816	....	10 667
7	...	....	2 456	....	....	.....
8	...	....	1 837	....	....	.....

of the milk handled in the unsteamed utensils gives approximately the number of bacteria contributed by the unsteamed pails, strainers, and cans. From the foregoing figures this difference is seen to be 306,135 bacteria per cubic centimeter for the milk handled in Barn I; 323,723 bacteria per cubic centimeter for the milk handled in Barn II; and 206,530 bacteria per cubic centimeter for the milk handled in Barn III. In other words, the unsteamed pails, strainers, and cans added to the milk 64 times as many bacteria as all the other sources of contamination at Barn I, 103 times as many in Barn II, and 18 times as many in Barn III.

TABLE 17.—GERM CONTENT OF MILK HANDLED IN UNSTEAMED PAILS, STRAINERS, AND CANS: BARN II

No. of can	April 27, 1915 a.m.	April 28, p.m.	April 29, p.m.	May 3, a.m.	May 3, p.m.	May 4, a.m.
	Number of bacteria per cc. of milk in cans					
1	212 000	89 200	18 400	828 000	118 700	426 200
2	310 000	363 500	52 800	852 000	77 100	575 000
3	97 300	275 800	21 500	410 500	83 900	254 700
4	123 500	111 200	32 800	1 124 000	195 800	237 000
5	120 000	123 600	35 100	369 000	61 500	554 000
6	124 700	422 500	62 300	703 000	111 100	445 000
7	133 700	485 000	73 500	......	143 200	......
	May 4, p.m.	**May 5, a.m.**	**May 5, p.m.**	**May 6, a.m.**	**May 6, p.m.**	**May 7, a.m.**
1	75 000	538 000	208 500	1 135 000	127 400	690 000
2	65 300	172 200	127 600	1 347 200	159 500	393 700
3	114 100	762 500	399 700	544 600	298 400	127 700
4	158 300	630 500	170 200	356 500	221 100	127 900
5	62 500	139 000	223 700	1 053 700	107 500	1 520 000
6	348 000	......	434 500	392 500	286 400	374 000
7	271 500	......	195 700	......	279 000	......

TABLE 18.—GERM CONTENT OF MILK HANDLED IN STEAMED PAILS, STRAINERS, AND CANS: BARN III

No. of can	May 11, 1915 p.m.	May 12, a.m.	May 12, p.m.	May 13, a.m.	June 1, p.m.	June 3, p.m.
	Number of bacteria per cc. of milk in cans					
1	8 295	41 150	9 652	17 405	5 442	6 027
2	7 980	10 737	3 782	4 833	13 112	20 490

TABLE 19.—GERM CONTENT OF MILK HANDLED IN UNSTEAMED PAILS, STRAINERS, AND CANS: BARN III

No. of can	May 3, 1915 a.m.	May 3, p.m.	May 4, a.m.	May 4, p.m.	May 5, a.m.	May 5, p.m.	May 6, a.m.	May 6, p.m.	May 7, a.m.
	Number of bacteria per cc. of milk in cans								
1	130 000	40 000	39 800	51 700	154 700	109 000	335 500	183 400	210 500
2	25 400	37 200	75 400	121 700	214 200	1 538 500	495 500	94 100	84 100

INFLUENCE OF UNSTEAMED BOTTLE FILLER UPON GERM CONTENT OF MILK

The bottle filler used for this experiment was the "double-end, four-quart and five-pint filler" shown in Fig. 1. It consisted of a tank and nine valves, each valve having a stem, a sleeve, an air tube, a wire coil spring, and a rubber washer.

In washing the bottle filler the valves were taken apart and placed inside the filler tank. The tank and all the parts were then scrubbed with a brush and washing powder and rinsed with a hose. After the bottler was cleaned in this manner, it remained standing in the milk room about twenty hours before it was used again. When it was to be steamed, it was covered with a galvanized iron lid, the valve openings were stopped with corks, and the steam was allowed to flow into it for thirty minutes. The steaming was done about one hour before bottling, and its thoroness was always tested by a bacteriological examination. The milk bottles were steamed in all cases.

From 300 to 400 quarts of milk were pasteurized and bottled each day. The milk was pasteurized in a vat; then cooled in the same vat by passing brine thru a coil revolving in the milk; and then it was bottled immediately. Samples of the milk were taken from the pasteurizing vat just before bottling, and then during the process, from the first bottle filled thru one of the four valves and then from every ninth bottle filled thru the same valve. Since there were four valves in the bottle filler, every ninth bottle filled thru one valve was actually every thirty-sixth bottle filled.

Table 20 gives the germ content of the milk when the bottle filler was steamed, and Table 21 when it was washed but not steamed. The bottles in both cases were steamed before being used.

TABLE 20.—GERM CONTENT OF PASTEURIZED AND BOTTLED MILK WHEN BOTTLE FILLER AND BOTTLES WERE STEAMED: DAIRY A

Samples of milk from:	Jan. 4, 1916	Jan. 5	Jan. 6	Jan. 7	Jan. 8	Average
	Number of bacteria per cc. of milk					
Pasteurizer	1 832	265	1 497	100	922	923
1st bottle	1 887	420	1 270	65	1 432	1 015
36th "	2 782	260	1 310	40	1 225	1 123
72d "	2 165	305	1 637	80	916	1 021
108th "	2 257	255	1 287	50	1 090	969
144th "	2 250	320	2 027	60	832	1 098
180th "	2 167	230	1 182	395	1 180	1 031

Table 20 shows that when the bottle filler was steamed shortly before use, the germ content of the bottled milk was approximately the same as that in the pasteurizing vat. If any increase took place, it was not measurable. When, however, the bottle filler, which had

TABLE 21.—GERM CONTENT OF PASTEURIZED AND BOTTLED MILK WHEN BOTTLE FILLER WAS NOT STEAMED: DAIRY A

Samples of milk from:	Dec. 17, 1915	Dec. 18	Dec. 19	Dec. 21	Dec. 22	Dec. 23	Dec. 24	Dec. 25	Dec. 29	Dec. 30	Average
	Number of bacteria per cc. of milk										
Pasteurizer	190	60	35	60	45	203	105	35	30	80	84
1st bottle.......	165 000	209 600	80 900	58 900	189 750	69 100	46 750	46 530	101 800	720	96 900
36th ,, ...	31 550	13 580	25 450	4 240	44 500	5 730	11 850	8 880	13 770	480	16 000
72d ,, ...	25 000	8 870	13 710	4 000	20 250	13 600	6 080	10 930	12 200	530	11 500
108th ,, ...	18 700	5 730	16 040	2 800	38 100	6 090	4 210	5 610	10 240	190	10 800
144th ,, ...	14 100	6 060	7 240	2 070	27 700	2 900	3 890	5 230	7 350	270	7 680
180th ,, ...	8 650	3 620	6 100	1 420	26 200	3 240	3 620	4 920	4 150	220	6 200
216th ,, ...	6 340	2 740	3 820	1 150	16 400	1 220	2 060	2 740	3 840	120	4 040
252d ,, ...	3 700	1 800	2 510	810	13 130	2 010	1 730	1 350	3 520	140	3 070
298th ,, ...	4 240	1 870	2 650	340	15 600	2 170	1 210	3 290	3 960	100	3 540
334th ,, ...	2 290	1 130	2 130	360	6 210	3 090	800	2 360	2 430	...	2 410
370th ,, ...	....	....	1 440	360	6 720	....	1 250	....	1 670	...	2 288

stood for twenty hours after washing, was not steamed, a conspicuous increase in the germ content of the bottled milk took place. Table 21 for instance, shows that on December 18 the germ content of the milk in the pasteurizing vat was but 60 bacteria per cubic centimeter while in the first bottle filled it was increased to 209,600 bacteria.

The averages shown in the last column in Table 21 present a striking illustration of the effect of the unsteamed bottle filler on the germ content of the milk passed thru it. The average germ content

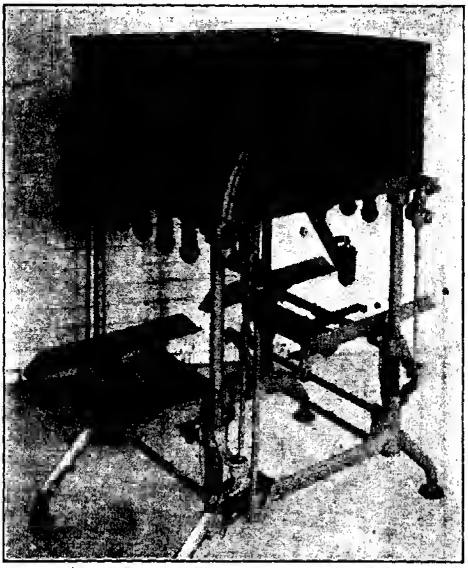


FIG. 1.—BOTTLE FILLER USED IN THE EXPERIMENT

of the milk before bottling was 84 bacteria per cubic centimeter; of the first bottle filled it was 96,900; and of the last bottle, 2,288. There was evidently a gradual washing out of the bacteria of the bottle filler by the milk passed thru it, the greatest proportion being removed by the first milk. However, the effect of the unsteamed bottler was evident even in the last bottle filled.

COLLECTIVE INFLUENCE OF UTENSILS AT THE BARN AND AT THE DAIRY

In the barn and in Dairy A, in which this study was conducted, about 100 to 200 quarts of milk came into contact with the utensils during the process of milking. The utensils used comprized five pails, two strainers, two weighing pails, one sanitary tube fifteen feet long,

TABLE 22.—GERM CONTENT OF BOTTLED MILK WHEN ALL UTENSILS WERE STEAMED: DAIRY A

Samples of milk from:	Sept. 18, 1914	Sept. 29	Oct. 1	Oct. 21	Oct. 26	Oct. 27	Oct. 28	Oct. 29	Oct. 31	Nov. 2
	Number of bacteria per cc. of milk									
1st bottle............	6 052	5 977	3 825	15 596	4 827	3 850	2 825	2 882	4 492	4 972
16th ”	6 262	6 850	3 820	7 502	2 890	3 957	3 787	3 297	4 455	4 937
36th ”	5 922	2 770	2 407	5 140	2 307	3 265	3 287	3 430	4 262	4 302
64th ”	4 542	2 600	3 406	....	....	....	....	....	....	....

TABLE 23.—GERM CONTENT OF BOTTLED MILK WHEN UTENSILS WERE NOT STEAMED: DAIRY A

Samples of milk from:	Sept. 29, 1914	Oct. 2	June 25, 1915	June 25	June 26	June 27	June 29	June 29	June 30	June 30	July 1	July 1
	Number of bacteria per cc. of milk											
1st bottle...	155 000	190 000	81 000	330 750	734 000	75 750	347 000	948 000	492 500	342 500	265 000	667 500
16th ” ...	60 500	210 000	64 500	410 500	1 085 000	760 000	319 500	684 750	175 500	99 687	208 250	161 250
36th ” ...	73 600	252 000	51 000	289 750	348 000	75 500	129 250	......	162 500	108 250	187 000	162 500
64th ” ...	84 875	......	127 500	......	408 000	68 000	56 000	......	123 500	100 875	339 000	128 750
96th ” ...	.....	......	.....	......	137 000	.....	59 400	......	190 000	......	......	......
124th ” ...	.....	......	.....	......	131 250	.....	76 600	......	......	......	......	......
144th ” ...	.....	......	.....	......	123 500	.....	......	......	......	......	......	......

one clarifier, one tubular cooler, five cans, one stirring dipper, and one bottle filler.

The utensils were steamed on certain days, while on other days they were only washed, rinsed, and placed on a rack until needed. The bottles were steamed in all cases.

The milk was bottled within two hours after milking, and the samples were taken from the consecutively filled bottles at definite intervals. The germ content of the milk samples from steamed utensils is shown in Table 22, and from unsteamed utensils in Table 23.

The influence of the unsteamed utensils is measured by the difference in the germ content of the milk handled in steamed and in unsteamed utensils. The germ content of the milk when steamed utensils were used represents approximately the extent of contamination from sources other than from the utensils. It is seen from Table 22 that in most cases the bottled milk handled in steamed utensils had less than 5,000 bacteria per cubic centimeter, and in only one case was the germ content over 10,000. On the other hand, when unsteamed utensils were used, as shown in Table 23, the germ content of the bottled milk became variable and high. The lowest count was 51,000 bacteria per cubic centimeter and the highest 1,085,000 bacteria.

These results show that unsteamed utensils were the most important source of bacterial contamination at this dairy. They also show that when the utensils were thoroly steamed, milk of certified quality was produced without any difficulty.

INFLUENCE OF INDIVIDUAL UTENSILS AT THE BARN AND AT THE DAIRY

This experiment on the influence of the individual utensils was carried on at the same barn and dairy as the preceding experiment. All the utensils were washed and rinsed about eight hours previous to use, and only the bottles were steamed. The effect of the utensils that hold milk, such as cans and pails, was measured from samples of milk taken directly from them. The effect of such utensils as strainers and clarifiers, thru which milk passes, was measured from samples taken from the milk after it had run into steamed cans.

At each milking two lots of milk, of about six gallons each, were passed one after the other thru each of the utensils up to the bottle filler, and samples of milk were removed after the milk came into contact with each utensil. Both lots of milk were then mixed in the bottle filler and bottled. The results of the bacteriological examination of these samples are presented in Table 24.

In the preceding experiments it was shown that when the utensils were steamed, the bottled milk at this dairy rarely exceeded 5,000 bacteria per cubic centimeter (see Table 22). It may be assumed, therefore, with reasonable certainty that the milk, when this experiment was performed, did not receive more than 5,000 bacteria per cubic

TABLE 24.—INCREASE IN GERM CONTENT OF MILK DUE TO THE VARIOUS UNSTEAMED UTENSILS: DAIRY A

(Number of bacteria per cc. of milk)

Germ content of milk due to barn factors plus:	Oct. 5, 1915, p.m.	Oct. 6, p.m.	Oct. 7, a.m.	Oct. 7, p.m.	Oct. 8, a.m.	Oct. 8, p.m.	Oct. 9, a.m.	Oct. 9, p.m.	Oct. 10, p.m.
First Lot of 25 Liters of Milk									
Three pails	5 150	34 350	91 000	74 750	183 500	76 750	63 500	87 250	107 000
Strainer	12 225	27 850	112 500	70 000	188 [illegible]00	60 000	62 750	122 500	132 750
Clarifier tank	15 250	39 225	105 750	77 250	172 250	58 000	72 250	136 250	189 250
Clarifier	30 000	101 700	152 250	280 750	246 500	90 500	346 250	568 000	1 622 500
Cooler	25 000	100 560	140 000	301 500	302 250	83 000	348 250	456 000	1 840 000
Second Lot of 25 Liters of Milk									
Three pails	10 575	18 860	41 500	42 250	54 500	25 250	37 500	67 750	52 000
Strainer	14 650	29 900	38 750	44 750	56 500	24 750	37 750	80 750	88 750
Clarifier tank	13 700	30 125	51 250	48 000	63 250	39 000	45 750	89 500	103 750
Clarifier	15 600	46 875	37 250	82 500	75 500	42 500	73 250	180 750	361 500
Cooler	18 425	53 925	51 500	92 750	89 500	43 750	94 750	225 250	543 750
The Two Lots of Milk Mixed in Bottle Filler									
Bottle-filler tank	54 250	167 500	196 250	272 250	281 000	107 250	344 000	446 750	1 385 000
1st bottle	189 000	1 479 000	987 500	634 000	500 000	600 000	550 000	785 000	1 415 000
9th "	.....	......	......	......	......	......	550 000	785 000	1 280 000
17th "	66 950	196 750	229 500	277 750	330 250	157 500	342 000	......	1 072 000
25th "	.....	......	......	......	......	......	......	587 500	....
33d "	51 875	192 000	200 500	308 000	308 250	207 500	482 250	......	....
41st "	.....	......	......	......	......	......	......	482 000	....

centimeter from the sources of contamination other than the utensils. The number of bacteria each utensil added to the milk and the cumulative effect of a number of utensils upon the germ content of the milk is very evident in Table 24. It is further emphasized in Table 25, where are shown the average numbers of bacteria that were added to the milk by each utensil and the average number per cubic centimeter of the milk.

TABLE 25.—AVERAGE NUMBER OF BACTERIA ADDED TO FIFTY LITERS OF MILK BY THE VARIOUS UNSTEAMED UTENSILS IN WHICH IT WAS HANDLED: DAIRY A

Source of bacteria	Number of bacteria per cc. of milk	Total number of bacteria
Sources other than utensils	5 000	250 000 000
3 pails	54 635	2 731 750 000
1 strainer	7 315	365 750 000
1 clarifier tank	8 038	401 900 000
1 clarifier	141 340	7 067 000 000
1 cooler	50 900	2 545 000 000
1 bottle-filler tank	83 246	4 162 300 000
Total	350 000	17 523 700 000
Total for utensils	345 000	17 273 700 000

Each utensil is seen to have contributed a different number of bacteria to the milk. The clarifier and the bottle filler were the most prolific sources. The clarifier added, on the average, 141,340 bacteria per cubic centimeter of the 50 liters of milk. The total number added by the bottle filler is difficult to estimate, since the valves of the filler added different numbers of bacteria to the consecutively filled bottles. A rough estimate shows that the tank and the four valves of the filler added approximately 436,000 bacteria per cubic centimeter of the milk.

It will be noticed from Table 24 that the first lot of 25 liters of milk passing thru the utensils became more heavily seeded with bacteria than the second lot of 25 liters. As the milk passed thru the valves of the filler into the bottles, the first bottles likewise became more heavily contaminated than those subsequently filled. There is a washing out of the bacteria from the utensil by the milk, so that the influence of a utensil depends on the amount of milk passed thru it as well as on the total number of bacteria in the utensil. It must therefore be borne in mind that in this experiment only 50 liters of milk came into contact with the utensils.

Considered as a whole, the accumulation of germ life in milk by contact with different utensils that are not steamed, frequently reaches a point where the keeping quality of the milk is seriously affected. The milk examined in this last experiment was less than two hours old. What would have been the germ content of this milk had its delivery to the consumer been delayed some twenty to forty hours, as happens in the milk business in large cities, is readily imagined.

SUMMARY

1. BACTERIA FOUND IN FRESHLY WASHED CANS.—An examination of 170 freshly washed but unsteamed milk cans showed the presence of large numbers of bacteria. Had these freshly washed cans been filled with sterile milk, the germ content of the milk would have varied from 197 to 2,557,000 bacteria per cubic centimeter and would have averaged 128,592 bacteria per cubic centimeter.

2. BACTERIA FOUND IN CANS THIRTY HOURS AFTER BEING WASHED.—Fifty cans washed, steamed, and left thirty hours uncovered and inverted on a rack, if filled with milk would have added to the milk an average of 8 bacteria per cubic centimeter. Fifty cans similarly cleansed but left thirty hours with the lids on, if filled with milk would have added to the milk an average of 1,816 bacteria per cubic centimeter.

Fifty cans washed but not steamed, and held thirty hours uncovered and inverted on a rack, if filled with milk would have added to the milk an average of 27,164 bacteria per cubic centimeter. Ten cans similarly cleansed but held thirty hours with the lids on, if filled with milk would have added to the milk an average of 128,730 bacteria per cubic centimeter.

3. BACTERIA FOUND IN CANS WASHED AND RETURNED TO THE FARM.—Ninety-one milk cans that had been washed, rinsed, and steamed at the dairy and covered with their lids, examined as they were about to be used on several dairy farms showed that had they been filled with milk they would have added to the milk an average of 23,523 bacteria per cubic centimeter. The treatment of these cans at the farms was not uniform, either as to their being kept covered or as to the length of time elapsing before their use.

4. SOURCES OF BACTERIA IN WASHED CANS.—A comparison of the germ content of each of 153 milk cans after the cans had been emptied and washed, but not rinsed or steamed, and the germ content of the milk previously held by the cans, in most cases revealed no direct relationship. However, taken in the whole, the dairy which received the milk with the higher germ content also had the cans with the higher germ content.

An examination of 134 freshly washed cans and of the water in which they were washed showed that the wash water became heavily seeded with bacteria during the washing process. However, the extremely large numbers of bacteria found in some of the washed cans could not be accounted for by contamination from the wash water. The most probable explanation of these extremely large numbers is that the bacteria are imbedded in small traces of grease and other matter on the inner walls of the can, and become loosened in the washing process.

5. BACTERIA FOUND IN BOTTLES FRESHLY WASHED AND IN BOTTLES STANDING TWENTY-FOUR HOURS.—An examination of 154 freshly washed but unsteamed milk bottles showed that had they been filled with sterile milk, the germ content of the milk would have averaged 1,339 bacteria per cubic centimeter, while an equal number of similar bottles, examined after an interval of twenty-four hours during which they had been left inverted on a rack, would have given a germ content to the milk of 12,930 bacteria per cubic centimeter.

6. COLLECTIVE INFLUENCE OF UTENSILS AT THE BARN.—An examination of 81 cans of milk at the farm ready for transportation to the dairy, when all utensils had been carefully steamed showed an average germ content of 6,807 bacteria per cubic centimeter. A similar examination of the milk in 117 cans from the same farms, when all utensils were similarly treated except that the steaming was omitted, showed an average germ content of 285,600 bacteria per cubic centimeter.

7. INFLUENCE OF UNSTEAMED BOTTLE FILLER UPON GERM CONTENT OF MILK.—When the bottle filler was carefully washed and steamed, it exerted no appreciable effect upon the germ content of the milk passing thru it. When it was similarly washed but not steamed, the germ content of the milk of the first bottle was increased on the average by 96,900 bacteria per cubic centimeter. The continued use of the bottle filler gradually washed the larger part of the germ life from the machine.

8. COLLECTIVE INFLUENCE OF UTENSILS AT THE BARN AND AT THE DAIRY.—A study of the collective influence of all the utensils that normally come into contact with the milk both at the barn and at the dairy showed that when all the utensils were carefully steamed the germ content of the milk in the bottles was about 4,566 bacteria per cubic centimeter. When similar conditions obtained except that the steaming of the utensils was omitted, the germ content of the milk approximated 257,240 bacteria per cubic centimeter.

9. INFLUENCE OF INDIVIDUAL UTENSILS AT THE BARN AND AT THE DAIRY.—Of all the various utensils coming into contact with the milk at the barn and at the dairy, the clarifier and the bottle filler when unsteamed proved to be the most prolific sources of contamination. The clarifier added an average of 141,340 bacteria per cubic centimeter to the fifty liters of milk passed thru it, while the bottle-filler tank and the four valves of the filler added approximately 436,000 bacteria per cubic centimeter to the same milk.

CONCLUSIONS

The fact that the dirt which falls into milk at the barn is readily visible in the milk has led to the conclusion that the barn is the principal source of the bacteria in milk. The results of this study, however, show that it is the utensils, rather than the barn, that are largely responsible for the excessive bacterial contamination of milk. The extent of the contamination of milk by the utensils is strikingly illustrated in one of the experiments in this study: when all the utensils commonly used for handling the milk at the barn and in the dairy were thoroly steamed, the bottled milk had uniformly only about 5,000 bacteria per cubic centimeter, but as soon as the steaming was omitted the bottled milk frequently contained several hundred thousand bacteria per cubic centimeter.

The cans used for shipping milk are a particularly prolific source of bacteria when they are washed at the dairy and returned to the farm without being thoroly steamed and dried. The number of bacteria usually added to the milk by such cans is many times larger than the number that would ordinarily get into the milk at the barn; the addition of a million bacteria per cubic centimeter of milk by such cans is not uncommon.

A detailed comparative study of the effect of the various other utensils at the barn and at the dairy suggests that the greatest contamination comes from the more complex apparatus, such as the clarifier and the bottle filler. In one of the experiments in this study, it was found that the pails added approximately eleven times as many bacteria to the milk as the barn influences, the strainer one and one-half times as many, the clarifier thirty times as many, the cooler ten times as many, and the bottle filler sixty times as many—a total of 112 times as many added by the utensils as by the barn factors.

It seems to the authors that in an attempt to produce milk with low germ content too much stress has been laid on practices of minor importance and the influence of utensils poorly steamed and not dried has been commonly neglected.